

1 What is claimed is:

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3 1. A high temperature flexible pipe joint comprising:

4 a body;

5 an extension pipe; and

6 a laminated elastomeric flex element coupling the extension pipe to the body, the
7 laminated elastomeric flex element having alternate elastomer layers and reinforcement
8 layers including inner layers near to the extension pipe and outer layers away from the
9 extension pipe, wherein the flex element is constructed to shift strain from the inner
10 elastomer layers to the outer elastomer layers.

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12 2. The high temperature flexible pipe joint as claimed in claim 1, wherein the
13 inner elastomer layers have greater shear area than the outer elastomer layers to shift
14 strain from the inner elastomer layers to the outer elastomer layers.

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16 3. The high temperature flexible pipe joint as claimed in claim 2, wherein the
17 inner reinforcement layers are configured different from the outer reinforcement layers so
18 that the inner elastomer layers have greater shear area than the outer elastomer layers.

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20 4. The high temperature flexible pipe joint as claimed in claim 3, wherein the
21 inner reinforcement layers are corrugated or pocketed.

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1 5. The high temperature flexible pipe joint as claimed in claim 1, wherein the
2 inner elastomer layers have a greater thickness than the outer elastomer layers.

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4 6. The high temperature flexible pipe joint as claimed in claim 1, wherein the
5 inner elastomer layers have a higher shear modulus than the outer elastomer layers.

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7 7. The high temperature flexible pipe joint as claimed in claim 1, wherein the
8 inner elastomer layers have a greater thickness than the outer elastomer layers, and the
9 inner elastomer layers have a higher shear modulus than the outer elastomer layers.

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11 8. The high temperature flexible pipe joint as claimed in claim 1, wherein the
12 inner elastomer layers have a higher temperature resistance than the outer elastomer
13 layers.

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15 9. The high temperature flexible pipe joint as claimed in claim 1, wherein at
16 least the inner elastomer layers are comprised of high temperature resistant elastomer.

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18 10. The high temperature flexible pipe joint as claimed in claim 9, wherein the
19 high temperature resistant elastomer is efficient vulcanized nitrile butadiene rubber.

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21 11. The high temperature flexible pipe joint as claimed in claim 9, wherein the
22 high temperature resistant elastomer is peroxide cured hydrogenated nitrile butadiene
23 rubber.

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12. The high temperature flexible pipe joint as claimed in claim 9, wherein the high temperature resistant elastomer is a fluoroelastomer.

13. The flexible pipe joint as claimed in claim 1, which includes a heat shield disposed in the extension pipe in the vicinity of the laminated elastomeric flex element.

14. The flexible pipe joint as claimed in claim 13, wherein the heat shield includes polymeric material.

15. The flexible pipe joint as claimed in claim 13, wherein the heat shield includes polyetheretherkeytone reinforced with glass fiber.

16. The flexible pipe joint as claimed in claim 13, wherein the heat shield includes low heat conductivity metal.

17. The flexible pipe joint as claimed in claim 13, wherein the heat shield includes non-metallic heat insulating material, and a metal cover that encloses the non-metallic heat insulating material and is welded to the extension pipe.

18. The flexible pipe joint as claimed in claim 13, wherein the heat shield includes a metal cover welded to the extension pipe, the metal cover enclosing at least one cavity.

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19. The flexible pipe joint as claimed in claim 13, wherein the heat shield includes non-metallic material inserted into the extension pipe, and a multi-section ring retaining the non-metallic material inserted into the extension pipe.

20. The flexible pipe joint as claimed in claim 19, wherein the multi-section ring is pinned to the non-metallic material inserted into the extension pipe.

21. The flexible pipe joint as claimed in claim 19, wherein the multi-section ring is inserted under a metal retaining ring welded to the extension pipe.

22. The flexible pipe joint as claimed in claim 13, wherein the extension pipe has a hemispherical portion in the vicinity of the laminated elastomeric flex element and a cylindrical portion away from the laminated elastomeric flex element, the heat shield includes a hemispherical portion mating with an inner profile of the hemispherical portion of the extension pipe, and the heat shield includes a cylindrical portion extending into the cylindrical portion of the extension pipe.

23. The flexible pipe joint as claimed in claim 1, wherein at least a portion of the extension pipe in the vicinity of the laminated elastomeric flex element includes low heat conductivity metal.

1 24. The flexible pipe joint as claimed in claim 23, wherein the extension pipe
2 includes a hemispherical portion in the vicinity of the elastomeric flex element, and the
3 hemispherical portion is made of nickel-chromium-iron alloy.

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5 25. The flexible pipe joint as claimed in claim 23, wherein the extension pipe
6 has a cylindrical portion made of steel.

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8 26. The flexible pipe joint as claimed in claim 1, wherein the body contains a
9 bellows secured to an end of the extension pipe within the body, the body defines an inner
10 annulus about the bellows, and the inner annulus is filled with a high temperature
11 resistant, substantially incompressible fluid.

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13 27. The flexible pipe joint as claimed in claim 26, wherein the substantially
14 incompressible fluid is a polyalkylene glycol solution.

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16 28. The flexible pipe joint as claimed in claim 26, wherein the bellows is
17 made of low heat conductivity metal.

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19 29. The flexible pipe joint as claimed in claim 28, wherein the low heat
20 conductivity metal is nickel-chromium-iron alloy.

1 30. The flexible pipe joint as claimed in claim 26, which includes at least one
2 baffle attached to the body and extending into the inner annulus in the vicinity of the
3 bellows and the laminated elastomeric flex element.

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5 31. The flexible pipe joint as claimed in claim 26, wherein the body has
6 external fins for dissipation of heat from the body, and the body has internal fins that
7 protrude into the inner annulus.

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9 32. The flexible pipe joint as claimed in claim 1, wherein the body has
10 external fins for dissipation of heat from the body.

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12 33. A high temperature flexible pipe joint comprising:
13 a body;
14 an extension pipe; and
15 a laminated elastomeric flex element coupling the extension pipe to the body, the
16 laminated elastomeric flex element having alternate elastomer layers and reinforcement
17 layers, and
18 a heat shield disposed in the extension pipe in the vicinity of the laminated
19 elastomeric flex element.

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21 34. The high temperature flexible pipe joint as claimed in claim 33, wherein
22 the elastomer layers include inner elastomer layers near to the extension pipe and outer
23 elastomer layers away from the extension pipe, wherein the inner elastomer layers have a

1 greater thickness than the outer elastomer layers, and the inner elastomer layers have a
2 greater shear modulus than the outer elastomer layers.

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4 35. The high temperature flexible pipe joint as claimed in claim 33, wherein
5 the elastomer layers include inner elastomer layers near to the extension pipe and outer
6 elastomer layers away from the extension pipe, the inner elastomer layers consist
7 essentially of peroxide cured hydrogenated nitrile butadiene rubber, and the outer
8 elastomer layers consist essentially of vulcanized nitrile butadiene rubber.

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10 36. The high temperature flexible pipe joint as claimed in claim 33, wherein
11 the elastomer layers include inner elastomer layers near to the extension pipe and outer
12 elastomer layers away from the extension pipe, the inner elastomer layers consist
13 essentially of fluoroelastomer, and outer elastomer layers consist essentially of vulcanized
14 nitrile butadiene rubber.

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16 37. The high temperature flexible pipe joint as claimed in claim 33, wherein
17 the reinforcement layers include inner reinforcement layers near to the extension pipe and
18 outer reinforcement layers away from the extension pipe, and the inner reinforcement
19 layers are corrugated or pocketed.

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21 38. The flexible pipe joint as claimed in claim 33, wherein the heat shield
22 includes polymeric material.

1 39. The flexible pipe joint as claimed in claim 33, wherein the heat shield
2 includes polyetheretherkeytone reinforced with glass fiber.

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4 40. The flexible pipe joint as claimed in claim 33, wherein the heat shield
5 includes low heat conductivity metal.

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7 41. The flexible pipe joint as claimed in claim 33, wherein the heat shield
8 includes non-metallic heat insulating material, and a metal cover that encloses the non-
9 metallic heat insulating material and is welded to the extension pipe.

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11 42. The flexible pipe joint as claimed in claim 33, wherein the heat shield
12 includes a metal cover welded to the extension pipe, the metal cover enclosing at least
13 one cavity.

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15 43. The flexible pipe joint as claimed in claim 33, wherein the heat shield
16 includes non-metallic material inserted into the extension pipe, and a multi-section ring
17 retaining the non-metallic material inserted into the extension pipe.

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19 44. The flexible pipe joint as claimed in claim 43, wherein the multi-section
20 ring is pinned to the non-metallic material inserted into the extension pipe.

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22 45. The flexible pipe joint as claimed in claim 43, wherein the multi-section
23 ring is inserted under a metal retaining ring welded to the extension pipe.

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2 46. The flexible pipe joint as claimed in claim 33, wherein the extension pipe
3 has a hemispherical portion in the vicinity of the laminated elastomeric flex element and a
4 cylindrical portion away from the laminated elastomeric flex element, the heat shield
5 includes a hemispherical portion mating with an inner profile of the hemispherical portion
6 of the extension pipe, and the heat shield includes a cylindrical portion extending into the
7 cylindrical portion of the extension pipe.

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9 47. The flexible pipe joint as claimed in claim 33, wherein at least a portion of
10 the extension pipe in the vicinity of the laminated elastomeric flex element includes low
11 heat conductivity metal.

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13 48. A high temperature flexible pipe joint for continuous operation over a
14 service life in excess of twenty years, the high temperature flexible pipe joint comprising:

15 a body;

16 an extension pipe; and

17 a laminated elastomeric flex element coupling the extension pipe to the body, the
18 laminated elastomeric flex element having alternate elastomer layers and reinforcement
19 layers including inner layers near to the extension pipe and outer layers away from the
20 extension pipe, wherein at least an innermost elastomer layer is made of high temperature
21 resistant elastomeric material, and wherein the laminated elastomeric flex element is
22 constructed to shift strain from the inner elastomer layers to the outer elastomer layers;
23 and

1 a heat shield disposed in the extension pipe in the vicinity of the laminated
2 elastomeric flex element;

3 wherein the extension pipe is made of low heat conductivity metal in the vicinity
4 of the laminated elastomeric flex element.

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6 49. The flexible pipe joint as claimed in claim 48, wherein the body contains a
7 bellows secured to an end of the extension pipe within the body, the body defines an inner
8 annulus about the bellows, and the inner annulus is filled with a high temperature
9 resistant, substantially incompressible fluid.

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11 50. The flexible pipe joint as claimed in claim 49, wherein the substantially
12 incompressible fluid is a polyalkylene glycol solution.

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14 51. The flexible pipe joint as claimed in claim 49, wherein the bellows is
15 made of low heat conductivity metal.

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17 52. The flexible pipe joint as claimed in claim 51, wherein the low heat
18 conductivity metal is nickel-chromium-iron alloy.

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20 53. The flexible pipe joint as claimed in claim 47, which includes at least one
21 baffle attached to the body and extending into the inner annulus in the vicinity of the
22 bellows and the laminated elastomeric flex element.

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1 54. The flexible pipe joint as claimed in claim 49, wherein the body has
2 external fins for dissipation of heat from the body, and the body has internal fins that
3 protrude into the inner annulus.

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5 55. The flexible pipe joint as claimed in claim 48, wherein the body has
6 external fins for dissipation of heat from the body.

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